Space Weather Technical Forecast

Issued on Monday, 25 December 2023 at 01:07 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of M-class flares throughout. Slight chance of glancing CME impacts day 3-4 (27-28 Dec), and G1 Minor geomagnetic storm intervals.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate activity with three M-class flares observed. Peak flare was M2.9 from AR3529 at 24/1118 UTC, with a further M2.6 also observed from this region at 24/1649 UTC. A further M1.1 was observed from over the southeast horizon at 24/1951 UTC. AR3529 is the largest of the seven regions on the disc, comprised of two well-separated leader and trailer spots, but with very small mixed polarity spots ahead of the main leader resulting in some slight complexification. Along with the interaction with a nearby filament, this likely resulted in the flare activity that was observed. Otherwise AR3530 exhibited some small growth, before stabilising as a small group, but with a very small mixed-polarity (delta) spot. All other spots remained small and simple

There are a number of filaments on the disc, and a few eruptions were observed and two were notable for producing CMEs that may have Earth-directed components. This including a large eruption off the northwest disc after 24/1100 UTC and a smaller eruption off the southwest at 24/1430 UTC, but visible as a coronal dimming. A couple of other CMEs were observed, however these were off the Earth-Sun line.

Solar Wind / Geomagnetic Activity: Solar winds were background to slightly elevated, and while an observed weak enhancement may have originated in a weak coronal hole, this is inconclusive with no clear observed source. Observed solar wind speeds observed by ACE were around 380-450km/s, which was supported by SOHO observations. However the observed wind speeds from DSCOVR were unreliable, likely due to solar wind density being below average. Total Interplanetary Magnetic Field (IMF), Bt, was Weak to Moderate 5-8nT, while the north-south component, Bz, was variable between -7nT and +7nT, but favoured a negative (southward) orientation at first. Phi angle was mainly positive (away from the Sun). Geomagnetic activity eased from mainly Unsettled to mainly Quiet (Kp 1-3).

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux was at Background levels. GOES16 high energy (greater than 2MeV) electron flux was mainly at background with a peak of 204 pfu at 24/0335UTC. The 24-hour fluence was below Active throughout and declining, with the 25/0000UTC observation being 3.20e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate activity is forecast with an ongoing chance of isolated M-flares.

Solar Wind / Geomagnetic Activity: There are two CMEs with the potential for Earth-directed components. The first from the NW filament eruption on 24 Dec, is expected to mainly miss to the north, but with a glancing impact possible on day 3 (27 Dec). The second from smaller the SW filament eruption and dimming on 24 Dec, with a glancing impact possible on day 4 (28 Dec). Both are low confidence. Otherwise, no notable enhancements are expected with solar winds persisting at background to slightly elevated throughout. Geomagnetic activity is expected to be mainly Quiet, but with a chance for spells of Unsettled to Active, with a slight chance G1

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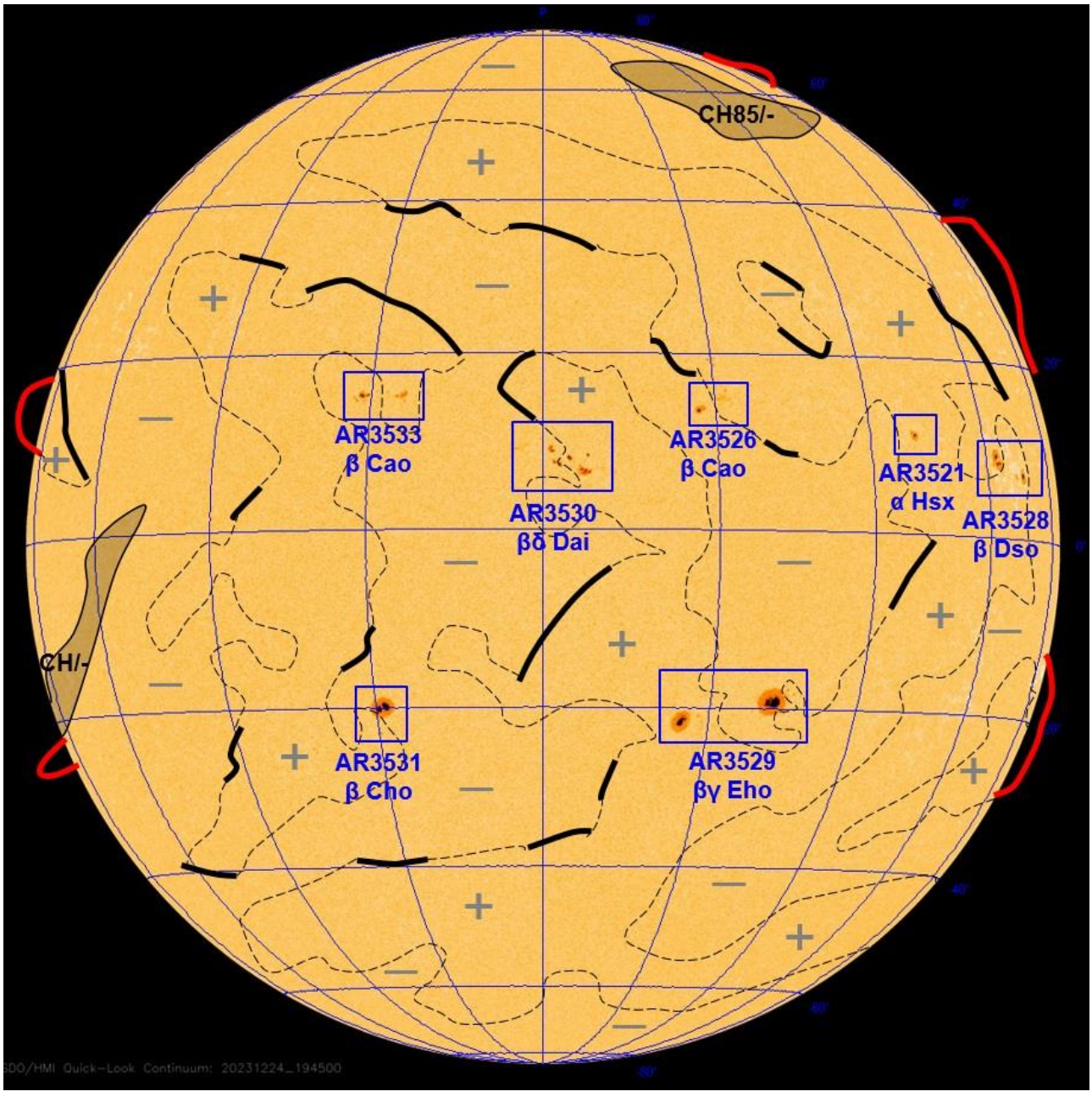
Minor Storm intervals, from any CME glances day 3 or day 4 (27-28 Dec).

Energetic Particles / Solar Radiation: GOES16 high energy proton flux is at background and likely to persist at this level, but with a slight chance of increasing given any further notable flares from AR3529 or other regions on the disc, especially as the move onto the western hemisphere. GOES16 high energy electron flux is expected to persist at mainly Background, with the associated fluence remaining below the Active level.

Figure 1. Solar Analysis Valid 24/2000 UTC.



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Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are two CMEs with potential Earth-directed components

The first was from a large filament eruption in the northeast disc, starting 24/1100UTC. There is some uncertainty with the projected latitude of the eruption, due to the broad nature of the CME, however a glancing impact is possible on day 3 (27 Dec), although this is low confidence. A slower CME was also observed off the southwest disc due to a filament eruption and a subsequent nearby coronal dimming visible in e.g. SDO aia-211 around 24/1430 UTC. This CME is still under analysis, however early indications are for a possible glancing impact, late on day 4 (28 Dec).

There are no notable coronal hole fast wind enhancements expected through the period, with winds expected to be mainly background to slightly elevated. Geomagnetic activity is expected to be mainly Quiet, but with a chance for spells of Unsettled to Active, with a slight chance G1 Minor Storm intervals, from any CME glances day 3 or day 4 (27-28 Dec)

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	1	20	20
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
12/1732	Nil	Filament	NW	850 km/s	27/0600 +12/-6 hrs	Low confidence. Bulk missing, chance of glancing impact.
12/2224	Nil	Filament	SW	572 km/s	28/1800 +/- 9hrs	Low confidence. Still under analysis, but glancing impact most likely.

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Figure 2a: Enlil and ensemble of potential CME glancing arrivals.

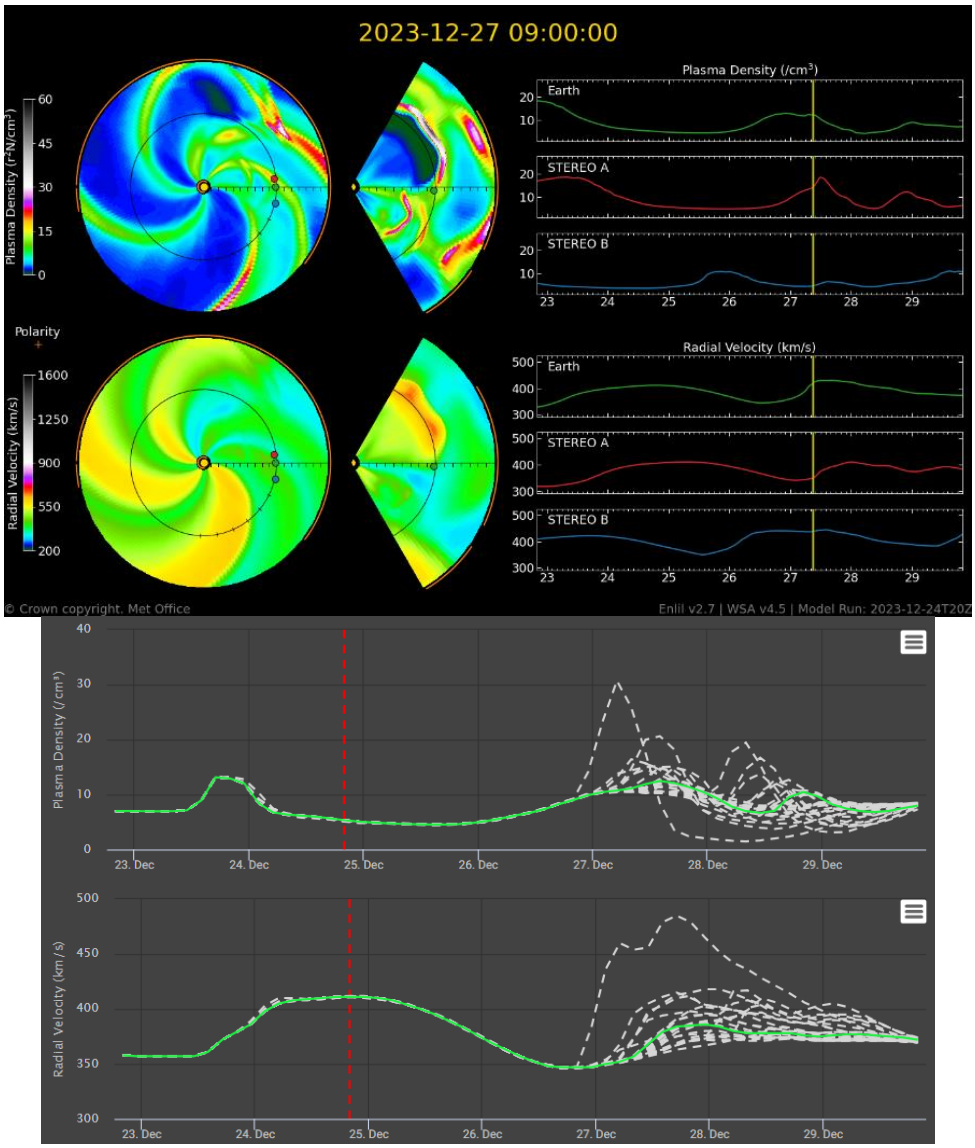
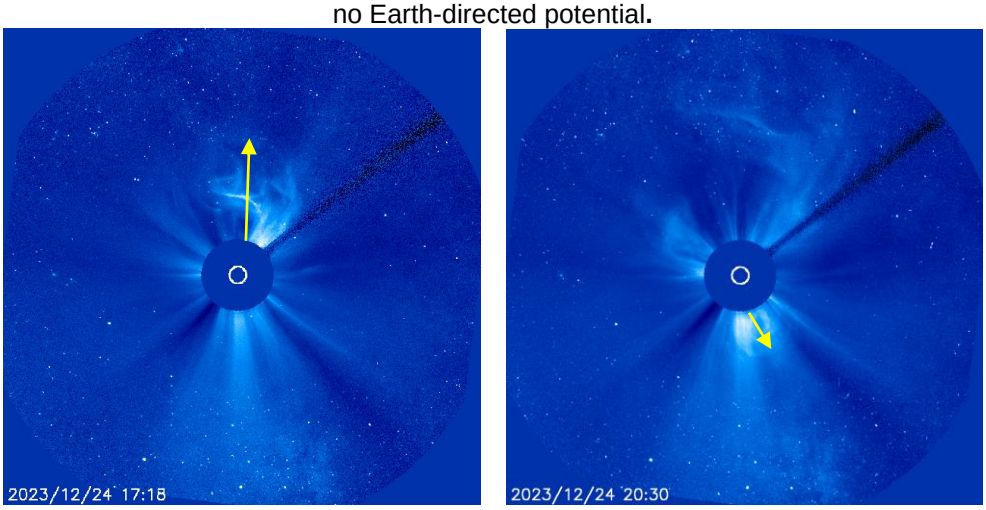


Figure 2b: SOHO-c3 coronagraph showing CMES to N (left) and to SW (right), along with other CMEs with no Earth-directed potential**.**



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Radio Blackouts - X-Ray Flares:

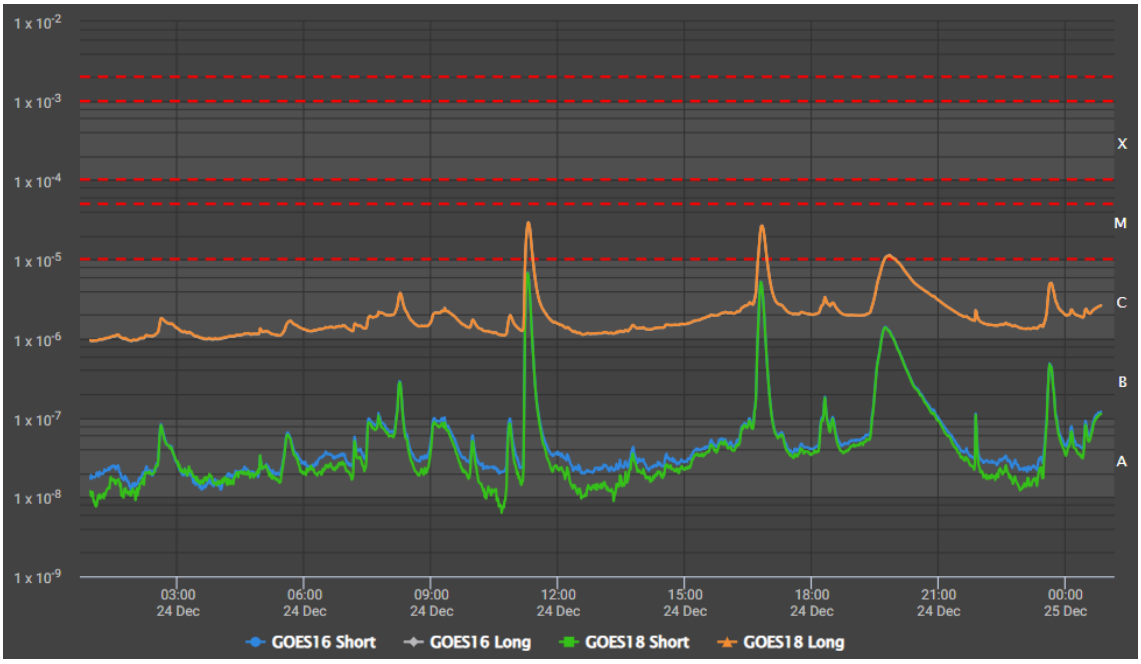
Low to Moderate activity is forecast with an ongoing chance of isolated M-class flares.

There are seven sunspot regions currently on the disc, including large region AR3529 in the in the southwest, which was the source of two M-flares on 24 Dec. This is an open group of two mature leader and trailer spots, but with some slight complexity around its leader, possibly due to interaction with a filament ahead of the spot. The other main flare risk is AR3530 in the north-centre disc. This has a very small delta spot, but is otherwise a relatively simple region. The other five regions remain smaller and simpler, with a lower but non-zero chance of producing M-flares.

A further M-flare was observed over the southwest limb on 24 Dec, and it remains to be seen if this is the precursor to a more active region rotating onto the disc, while a distinct area of magnetic looping visible on SDO-171 in the northeast, also suggests the potential for further regions to rotate onto the disc. These also give a further potential M-flare source.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	55	50	45
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES-16 X-ray Flux



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Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 has been at background, and is likely to persist at these levels. There is a slight chance of enhancement if any further M-flare activity was to occur from AR3529, or from any of the other spots, particularly as they move into the western hemisphere.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) observed by GOES-16 is at background, With any recent solar wind enhancement subdued, and no further coronal hole features in the forecast, mainly background flux is expected to persist for much of the period, although brief periods of Moderate flux are likely. There are two CME glancing impacts possible day 3 and day 4 (27-28 Dec), and these are likely to subdue any observed flux until either later day 4, or more likely beyond this period.

The associated 24 hr fluence is expected to persist below Active (1e8 pfu). This is supported by REFM, which is currently providing good guidance.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	1
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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